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On the nest and web structure of Latrodectus in South Africa, and some observations on body colouration of L. geometricus (Araneae: Theridiidae)

by

B. H. Lamoral

(Natal Museum, Pietermaritzburg)

SYNOPSIS

The structure and position of the refuge built by the two species of *Latrodectus* in South Africa are described. The refuge of *L. geometricus* varies in shape according to the habitat chosen. The walls are of thick silk and the refuge will either have two openings, namely a main and a secondary opening, or just a main opening. These openings were found to have delaying threads. The refuges are to be found in any useable, sheltered place.

The refuge built by *L. mactans* was found to differ in several ways and is described here for the first time. A secondary opening is seldom found and the refuge consists of three parts, namely the refuge proper with thick silk wall, a "tunnel" of silk leading away from the refuge and the delaying threads around the main opening. Most refuges investigated were built among grass or at the foot of stubble. A description is given as to how *L. mactans* makes use of this material to cover and camouflage her refuge with a tent like structure.

The webs of the two species of *Latrodectus* are shown to be three dimensional snares composed of two main parts, an aerial part made of ordinary non sticky silk and a terrestrial part composed of vertical viscid threads anchored to the ground.

The general belief that all Theridiid webs are disorganised and structureless is discussed. An attempt is made to show that in at least four species of Theridiids the webs are composed of two structurally different groups of silk threads. These are what have been termed the leading threads and the interconnecting threads. Their distribution and function is shown to be different. An attempt is also made at showing that the four Theridiids studied rely on tension differences in the various silk components of their webs, to find their way back to their refuge.

Finally it is reported that specimens of *L. geometricus* were found to match the ground colouration of their body to their habitat.

CONTENTS

INTRODUCTION

This study concerns the species *Latrodectus mactans* (Fabricius, 1775) and *Latrodectus geometricus* C. L. Koch 1841. The nomenclature adopted here is that of Levi (1959). To conserve older usage, as suggested by Levi, *L. mactans cinctus* is acceptable as a trinomial for populations of the former species occurring in Southern Africa.

It is aimed to supply new information on the following subjects:

1. The structure and position of the refuge built by the two species of *Latrodectus.*
2. The nature and position of the web.
3. The detailed structure and function of the webs built by *Latrodectus* and two other Theridiids.
4. The body colouration of *L. geometricus.*

L. geometricus and *L. mactans* (formerly known as *L. indistinctus* O.P. Cambridge) are common in the Cape Province as well as the rest of South Africa. While *L. geometricus* is widely distributed, specially near human dwellings, *L. mactans* has only rarely been recorded near or in human settlements. In addition *L. mactans* was found to be very abundant in the Cape wheat belt (Piquetberg, Malmesbury, Tulbagh, Paarl, Wellington, Worcester and Caledon administrative divisions of the Western Cape), particularly at the onset of summer. More detailed information on the distribution of the two species may be found in Smither's 1944 paper.

L. mactans is known to the South African public as the "Button-spider," as the "Rooigat-spinnekop" to the inhabitants of the Cape wheat belt and as the "Black Widow spider" in America. Complementary information of various aspects of "Latrodectism" may be found in the various references listed at the end of this paper.

1. THE STRUCTURE AND POSITION OF THE REFUGE BUILT BY THE TWO SPECIES OF *LATRODECTUS.*

(i) *L. geometricus:*

L. geometricus usually builds a refuge with either one or two openings. Fig. 1 shows a refuge with only one opening.

The overall shape of the refuge does not follow a general pattern and varies greatly according to the place where it was built. It was found, for instance, that all refuges built on a structure with only one sharp angle had only one entrance. Refuges built on uneven sites had a second opening. In this latter case, one opening leads to the web, and is here termed the *main opening.* The second opening is situated on the other side of the refuge and is termed the *secondary opening* (see fig. 2).

When disturbed in its refuge by a knitting needle pushed through the main opening, the spider invariably dashes out through the secondary opening and takes refuge in surrounding nooks and corners or simply drops to the ground in a cataleptic state. This secondary opening is thus a useful device that enables the spider to escape would-be predators. At first it may seem that this reduces the efficiency of the refuge since the spider could be attacked through its "back door." A close look at the refuge will however show that:

(*a*) The refuge is usually spacious enough to allow the spider to turn round to face any trespasser.

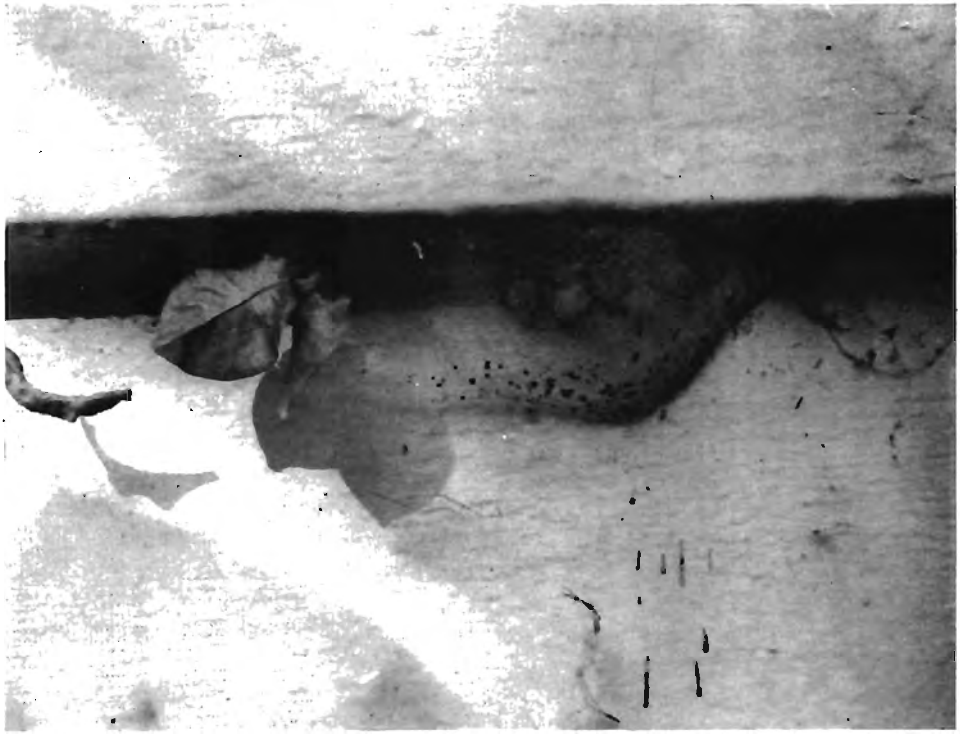

Fig. 1. Closeup of a refuge of *L. geometricus* built under a wall ledge. This refuge has only one opening, situated on the left hand side, behind the set of leaves. Five eggsacks are just visible inside the refuge. Scale ½ normal size.

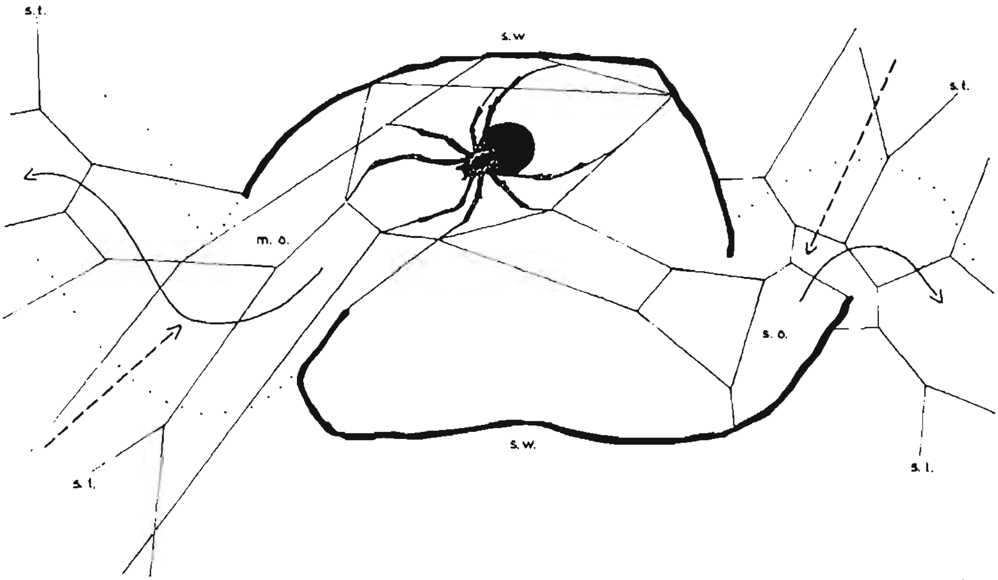

Fig. 2. Diagrammatic cross-sectional representation of a refuge of *L. geometricus* with two openings. m.o., main opening; s.o., secondary opening; s.t., silk threads of the web; s.w , thick silk wall of the refuge; ——> , path followed by the spider when leaving or entering its refuge;— — > , path that would-be predator is likely to follow; . . . . . ., delaying threads running somewhat perpendicularly to the plane of the diagram.

(*b*) The secondary opening as well as the main one were found to be equipped with delaying threads. These consists of fine silk threads stretched across the entrance in a more or less perpendicular direction. Their presumed function is to warn the spider of the approach of any possible predator and possibly to delay it. This forewarning usually enables the spider to escape through the other opening. It was interesting to note that these delaying threads form a sort of passage that often takes a twisting or S shaped course at either opening (see fig. 2). The spider was found to be aware of these delaying threads and to enter or leave its refuge without breaking them (see fig. 2).

The refuge of *L. geometricus* is thus seen to consist of two distinct portions, namely the refuge proper, with fairly thick silk walls, and the delaying threads around the openings to the refuge.

The nature of the site chosen by *L. geometricus* for its refuge was found to vary tremendously. A few sites, such as under windowsills, porch roofs and wall ledges, were found to be favourites. Besides these, old tins, summer houses, outbuildings, tool sheds, stony structures, wooden flower supports, awnings and even the undersides of cars are but a few examples.

L. geometricus is nocturnal in habit, and weather permitting, will only build its refuge at night. The female was found to start working shortly after dusk.

(ii) *L. mactans:* (figs. 3, 4, 5 & 6)

The refuge of *L. mactans* differs from that of *L. geometricus* in several ways. A secondary opening is very seldom found. The refuge itself consists of 3 distinct portions, namely the refuge proper with thick silk walls, the "tunnel" and the delaying threads. The "tunnel" silk wall varies in thickness, being thickest at its proximal end and thinning towards its distal end. The delaying threads are mainly found in and around the distal end of the "tunnel."

Contrary to *L. geometricus*, the overall shape and construction of the refuge of *L. mactans* does follow this general pattern and varies very little, specially when built in grass. Added to this, all nests of *L. mactans* that were investigated were never found higher than 0.3 metre from the ground.

Most of the refuges investigated were situated at the base of tufts of grass or stubble. Refuges were however also found at the base of small bushes, among heaps of loose debris, various ground depressions, rock crevices, under stone ledges and even in old tins. The refuges built at the base of tufts of grass or stubble deserve special attention. As a matter of fact the "tuft of grass" referred to by former investigators is not just any tuft of grass.
Careful observations in the field and experiments with laboratory specimens have shown that when building its refuge in low grasses or among stubble *L. mactans* proceeds as described hereafter (see fig. 4).

After selection of a site, (fig. 4a), an adult female of *L. mactans* will first clear the area where she wants to build her silk refuge. To achieve this she will climb to the top of the grass blades, with her body dangling in a direction radially away from the centre of the chosen site. She will carry on climbing until the blade of grass starts bending under the stress of the weight. When the grass offers too much resistance she usually drops to the ground after fastening a silk thread to the blade apex and then proceeds pulling it down. The

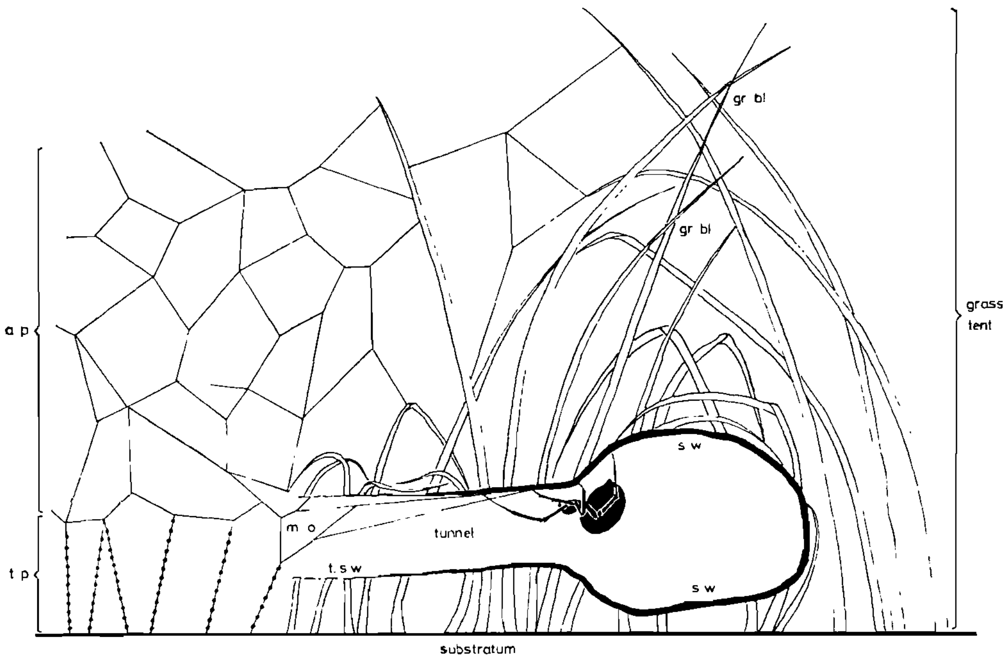

Fig. 3. Sagittal diagrammatic representation of a nest built by *L. mactans* when making use of grass. a.p., aerial part of the web; gr.bl., grass blades forming the tent; m.o., main opening of the refuge and region where the delaying threads are usually found; s.w., thick silk wall of the refuge; t.p., terrestrial part of the web; t.s.w., thin silk wall at distal end of the tunnel.

grass blades "flattened" to the ground are usually secured to peripheral upright blades, thus giving the result diagrammatically represented in fig. 4b.

The next step is to weave the refuge proper with its tunnel in and around the periphery of this grass depression (fig. 4c). When this is achieved, *L. mactans* then proceeds in bending the peripheral upright grass blades above and towards the centre of her silk refuge (arrows in fig. 4c). To achieve this she usually uses the same methods, as described above, to clear her site. In this instance however she will climb grass blades with her body dangling radially towards the centre of the chosen site.

She will camouflage all the silk components of her refuge in this manner (figs. 3, 4d, 5, 6). The whole structure or nest (refuge and grass covering) could well be described as "a silken igloo covered and camouflaged by a grass tent."

In figures 5 and 6, the grass that is not part of the nest has been cut away to facilitate photography. Under normal conditions, however, it is extremely difficult for the untrained observer to pick out the tent structure of the nest. Even when picked out from surrounding grass, the nest suggests more a tuft of grass than anything else.

Like *L. geometricus*, *L. mactans* is exclusively nocturnal and the structure described above is built only at night, weather permitting.

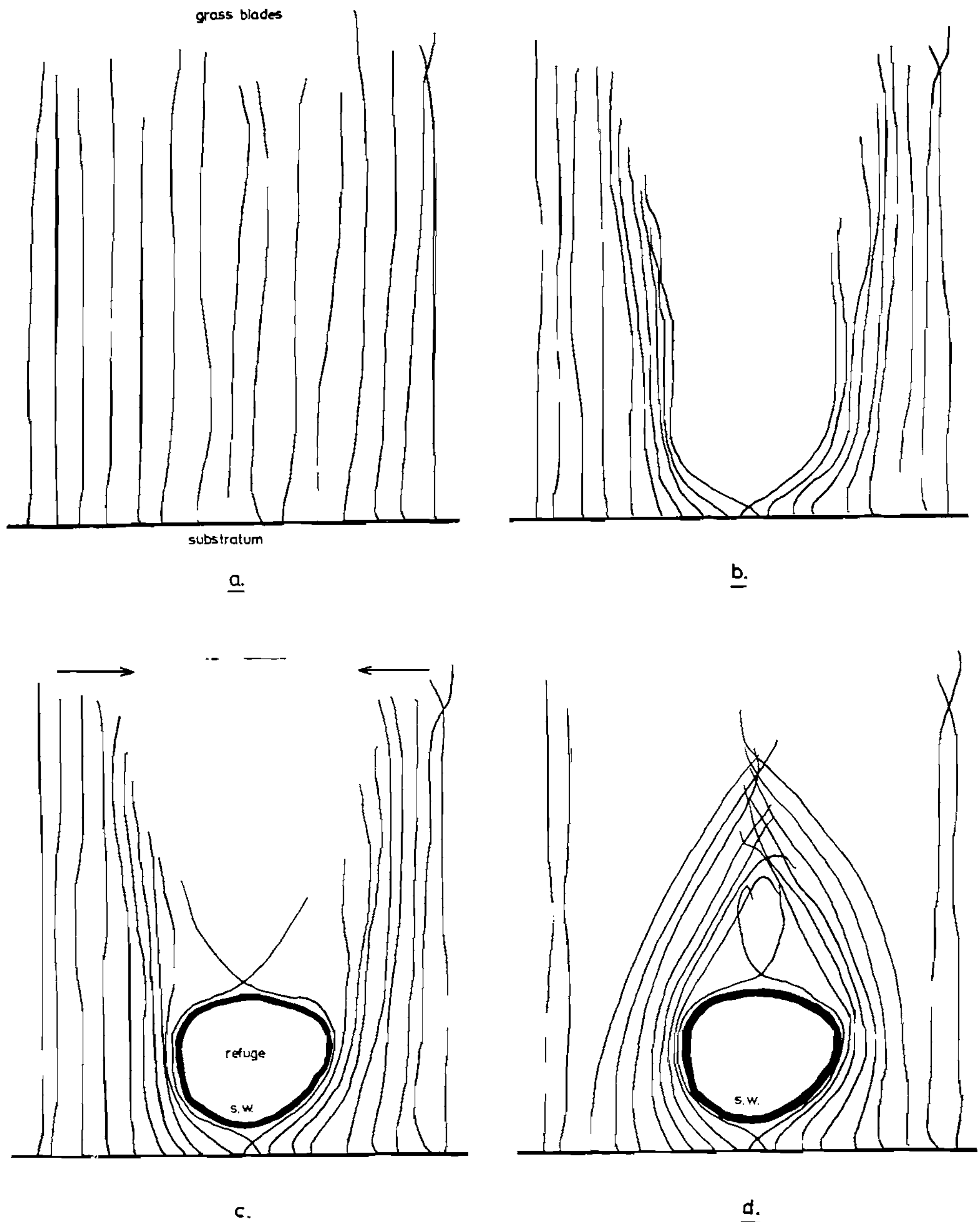

Fig. 4, a to d. Diagrammatic representation of the steps followed by *L. mactans* when building its refuge in grass. In c and d the refuge is seen cross-sectionally with the plane of the page perpendicular to the axis of the tunnel. See text for explanation of the steps followed by the spider.

2. DESCRIPTION AND POSITION OF THE WEB.

Both species of *Latrodectus* were found to follow the general Theridiid pattern in building their web. The finished web of adult specimens was found to be a three dimensional structure composed of two main parts, namely an aerial part, made of an apparently haphazard tangle of threads crossing and recrossing in all directions, and a terrestrial part composed of vertical and more or less distinct threads with their lower ends covered with a row of viscid drops. The vertical threads of the terrestrial part are anchored to the ground, and the threads of the aerial part are fastened to surrounding vegetation or other aerial components of the habitat.

L. mactans was found to adhere to this basic structure fairly constantly, (fig. 3), regardless of where it had built its refuge. The web is constructed shortly after dusk, and before sunrise is invariably destroyed, probably by the spider. The web is always close to the ground and its highest point is seldom higher than 0.5m.

L. geometricus, although following the basic pattern described above, will adapt its web structure to the position of its refuge. When the refuge is near the ground the female will construct her web in the same way as *L. mactans*. When her refuge is beyond 1.50 m from the ground, she will either come down nearer to the ground after dusk to build a conventional web with or without a secondary temporary refuge, or she will build a web at the same level as that of her refuge. In the latter instance her snare will lack the vertical viscid threads of the terrestrial part of the conventional *Latrodectus* web.

The generalised *Latrodectus* web, with its aerial and terrestrial parts, is an ingenious device which enables these spiders to snare insects of two different types. The aerial part will check the passage of flying insects of many kinds. The terrestrial portion will contribute in catching crawling insects. One might point out that the absence of any viscid threads in the aerial portion will decrease the efficiency of the web. While this was found to be true to a certain extent, it was also found on the other hand, that many flying insects, in their struggle to get out of the web, invariably "sink" nearer to the ground, eventually reaching it, should the spider be slow. Once they have reached the ground, they cannot fly off because of the overhanging threads. They thus have to crawl out. In doing this they however become stuck to the vertical viscid threads of the terrestrial part of the web.

It is for this reason that very few *L. geometricus* will build an aerial web near their refuge when it happens to be above 1.5 metres from the ground level. They usually prefer to come down and build their webs with a terrestrial part.

3. THE DETAILED STRUCTURE AND FUNCTION OF THE WEBS BUILT BY *LATRODECTUS* AND TWO OTHER THERIDIIDS.

Earlier in the text, the aerial part of the *Latrodectus* web was described as "an apparently haphazard tangle of threads." The authors of all available papers dealing with the subject invariably refer to the webs of all Theridiids as "merely a tangle of threads" (Savory 1952, p. 122); "... composed of threads extending in all directions with no apparent regularity" (Comstock 1913, p. 331); "Ce sont des fils tendus dans tous les sens sans ordre apparent;" (Berland 1932, p. 212), to quote but a few. Savory 1952, p. 123, further writes: "It has been stated that in the making of this apparently haphazard tangle of threads, cross-

ing and recrossing in all directions, a system or design is detectable. The nature of this system has, however, never been described more fully, and it may be suspected that the design existed in the mind of the observer rather than in the forces propelling the spider."

Careful observations and experiments made in the course of this investigation, on the other hand, strongly support the view that there is an underlying structure to the criss-

Fig. 5. Lateral view of a nest built by *L. mactans* near Mamre (Cape). The grass tent covering the refuge is visible on the right hand side. The tunnel, covered with bent grass blades, is on the left side. On the extreme left is a vertical stick showing where the main opening to the nest is. It is in this vicinity that delaying threads are found. Grass blades not pertaining to the nest were cut away to allow photographing. Scale $\frac{1}{5}$ actual size. (*Photo A. Fricke*).

cross scaffolding webs built by several Theridiids. For this purpose, the webs of *Steatoda lepida** (O. Pickard Cambridge 1904) and *Theridion purcellii* O. Pickard Cambridge 1904, were studied along with those of the two *Latrodectus* species.

Steatoda lepida is abundantly found throughout the Cape Peninsula under stones and at the base of small bushes and grass patches. To the non-specialist this spider looks very much like *L. mactans* though smaller in size. The composition and position of its web is very much like that of *L. mactans*. The nest of *S. lepida* is however different from that of *L. mactans*. It merely consists of a silk refuge similar to that of *L. geometricus* and it may be found at various heights.

Theridion purcellii is also found in great numbers throughout the Cape Peninsula. It is slightly smaller than *S. lepida* and is found in situations similar to *L. geometricus*. Its

*Levi (1962, p. 28) established that *Teutana* Simon, 1881, was a synonym of *Steatoda* Sundevall, 1883.

web is very similar to that of *L. geometricus* and, like it, sometimes lacks the terrestrial part. Its refuge is very much like that of *L. geometricus* but smaller.

By means of observations and experiments, it has been found that the webs of the above four species of Theridiids are basically composed of two types of silk threads. This does not imply that the nature of the silk of these two types of threads is different, but rather that these threads have different functions and spatial distributions affecting the efficiency of the snare. The two kinds of threads will be referred to as the *leading threads* and the *interconnecting threads*, abbreviated to L threads and I threads respectively.

To understand the importance of such a distinction it is best to follow the procedure observed by any of the above spiders in building its web. An adult female of *S. lepida* will be chosen in this instance. This spider, like *L. mactans* builds a new web every night, starting at nightfall. The steps followed are actually quite simple. The spider will first lay several threads radiating out of its refuge towards surrounding objects. These are the leading threads (P.L.T. fig. 7a). These may also be termed the primary L threads. To these and at a certain distance outside the refuge the spider will then add secondary L threads (S.L.T. fig. 7a). In the same way she might, add tertiary and so on, L threads, this depending mainly on the ultimate dimensions of the whole web. When these have all been laid, the spider will then proceed to interconnect the various leading threads with shorter threads. These are the interconnecting threads (fig. 7b).

I threads connecting adjoining L threads may be referred to as primary I threads. These will in turn be interconnected by more I threads—secondary I threads. In this fashion one may get tertiary, and so on, I threads (see fig. 7b). The terrestrial part of the web is then laid down, using viscid silk. The final result is the apparent tangle of threads so often referred to. By the time the web is completed it has become almost impossible to pick out the L threads from the I threads. It must be borne in mind that the webs of the spiders investigated are three dimensional structures and consequently the distribution and ultimate distortion of the leading threads will also be three dimensional. When observing the web spinning procedure it was found useful to label the L threads at several points along their length, with a brush pen containing a bright red, quick-drying dye. All four species of Theridiids mentioned earlier were found to use this pattern when spinning their webs. Specimens of three species were tested at night in the field and in captivity.

Latrodectus mactans was not tested in the field, as this presented some danger stemming mainly from the difficulty of knowing the whereabouts of other specimens while observing a specific specimen. *L. mactans* was however thoroughly tested in captivity. All specimens tested in captivity were given three dimensional frames of different sizes, with thin wires stretched across the sides, to build their webs within their confines.

While experimenting on these webs another research project was initiated. This involved, amongst other things, attempts to interbreed specimens of *L. mactans* from the United States and South Africa. Unfortunately, for unknown reasons, the *L. mactans* from the United States did not survive their journey for long and the project had to be abandoned. Notwithstanding this, the web structure of the ten specimens obtained from Phoenix, Arizona, was investigated. The webs were found to follow the general *Latrodectus* pattern herein described.

Fig. 6. Frontal view of the nest of *L. mactans* shown in fig. 5. The distal end of the tunnel has been removed to show its proximal end which is in the lower central part of the figure. This figure also illustrates how the spider bent and assembled the grass blades to form the tent. Scale ½ actual size. (*Photo A. Fricke.*)

The contention "the design existed in the mind of the observer rather than in the forces propelling the spider" (Savory 1952, p. 123), seems to be invalidated by the following observations;

(i) All spiders investigated invariably wait for prey, suspended from or having their legs in contact with the leading threads that radiate away from their refuge. As soon as any insect becomes entangled in her web, the spider quickly touches all the leading threads with one of her front legs. She then rushes out of her refuge following one of them. She will pause whenever she reaches an "intersection" and tap the thread to ascertain that she is following the right direction. The vibration set up by the struggling insect will be transmitted from the various kinds of interconnecting threads up to the tertiary, secondary and primary leading threads that supply the area where the insect was caught. The spider will thus move towards the source of vibration following the supply line in opposite direction. Of particular importance to substantiate the importance of a structural differentiation of the web, is the fact that whenever the spider had taken a "wrong turn" in its rush to get to the struggling insect, she would invariably go back to the previous junction or even further back, in order to correct her error, rather than rush any further.

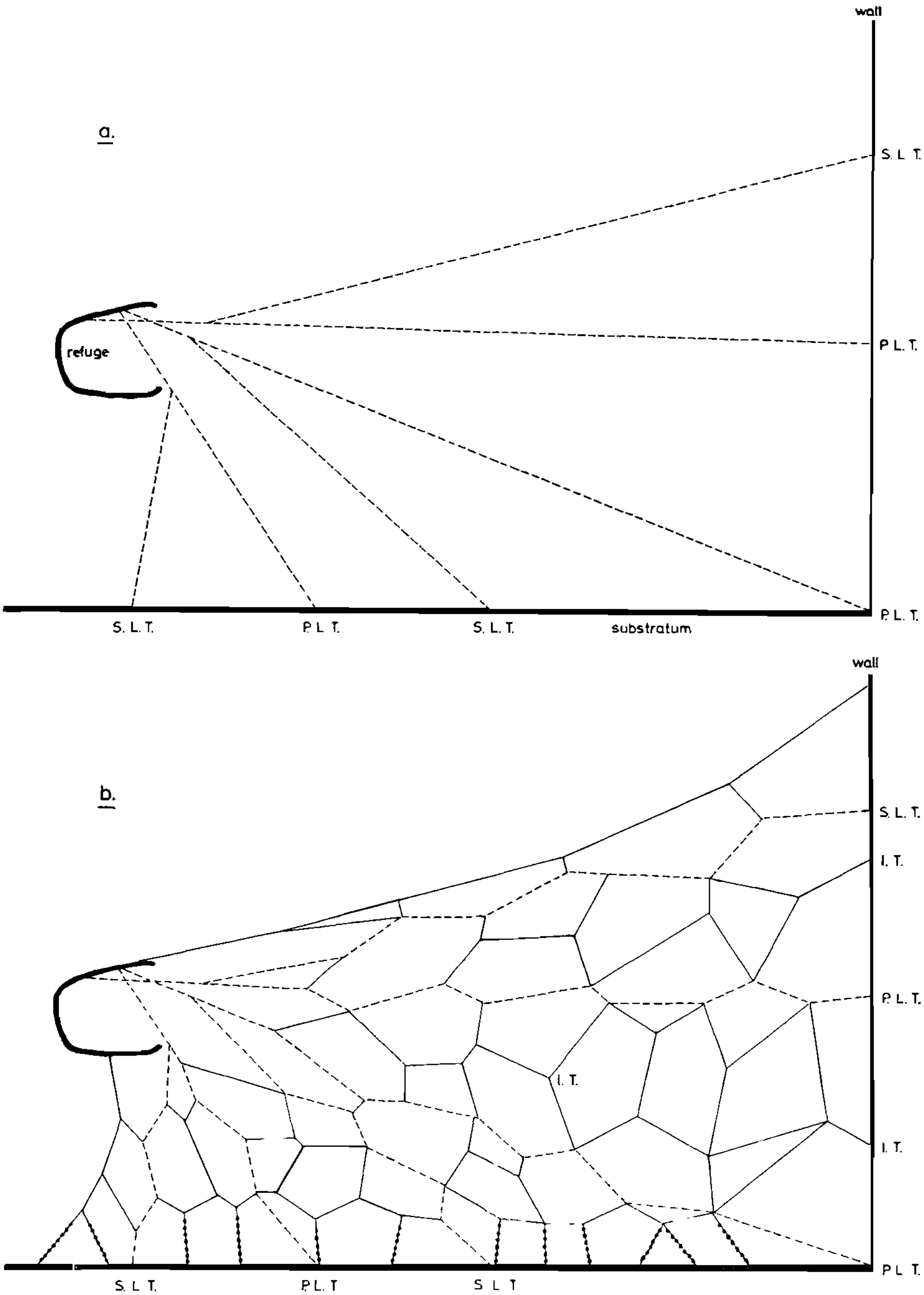

Fig. 7 a and b. Diagrammatic illustration of the steps followed by an adult female of *Steatoda lepida* in building its web. I.T., interconnecting threads; P.L.T., primary leading threads; S.L.T., secondary leading thread. See text for further explanations.

(ii) After cutting all the primary and secondary L threads at a certain distance from the refuge and dropping an insect in the web, it was found that the spider had great difficulty in locating prey, even though the vibrations set up by the struggling insect were reaching the spider via various I threads.. The spider only managed to locate prey once she had got beyond the point where the L threads had been cut. This shows how heavily the spider relies on the L threads and general organisation of its web and at the same time exposes the existence of a design or structure in the web of at least four Theridiids.

This latter experiment led to the solving of another interesting problem, namely how the spider finds its way back to the refuge after catching prey. In this instance the spider does not have a vibratory stimulus to facilitate its orientation.

Savory (p. 135-137, 1952) describes how Holzapfel solved this problem in the case of *Agelena labyrinthica*, by showing that this spider returns straight to her refuge, because she has constructed her sheet web so as to have the line of greatest tension in her web leading towards the refuge.

Being informed on the structure of the web of the four Theridiid studied, one would expect that a similar situation enables these spiders to find their way back. As a matter of fact one would expect that the spider would experience an increasing gradation in tension as she moves from an interconnecting thread towards the tertiary, secondary and finally the primary thread leading to her refuge.

One way to test this hypothesis was somehow to alter the tension of the various threads composing the webs of the Theridiids studied. This problem was solved by slightly squeezing and thus changing the shapes of the frames used by the specimens in captivity to build their webs. The squeezing was done so as to transfer the main direction of tension to a general line of tension leading in a direction diagonally perpendicular to the line of tension in a normal web. The results obtained seem conclusive. When the tension distribution was altered as described, the spider would invariably follow the new line of tension when trying to return to her refuge. It was found to be incapable of finding the refuge. When the supporting frame was brought back to its original position, the spider would then find its way to the refuge quite easily.

When the leading threads were cut it was also found that the spider could not find its refuge. Cutting of several interconnecting threads, though retarding the spider, did not prevent her finding her refuge.

If one of the Theridiids studied was taken from its web and introduced to an intra-specific web with completely different location of the refuge, it was found that, though hesitant in her general movement, the spider would not only find the refuge quite readily but also follow the graded line of tension described in this paper. When transferring a spider to the webs of the other species studied, similar, though not as conclusive, results were obtained. *Steatoda lepida* and *Theridion purcellii* had no trouble in finding their way about each other's and the *Latrodectus* species webs. The *Latrodectus* species managed well in each other's webs, but showed completely negative results in the webs of the two other Theridiids. This could be due to the web size as well as spider size differences between the two *Latrodectus* species and the other two.

Levi and Levi (1962, p. 67) have drawn a chart representing characters believed to be of phylogenetic importance for the genera of American Theridiidae. This chart shows that the genera *Latrodectus* and *Steatoda* are closely related whereas the genus *Theridion* is not related to the above two by any of the key characters used in the chart. It is thus of interest to note that the existence of a structural differentiation has been shown to occur in at least two phylogenetically unrelated groups of genera among the Theridiidae. However, one cannot infer from this that all Theridiid webs will display the organisation herein described. Only further investigation could substantiate this. When this has been achieved and a clearer picture is obtained, one may find the information obtained to be relevant to a reappraisal of web phylogeny for the families related to the Theridiids.

4. OBSERVATIONS ON BODY COLOURATION OF *L. GEOMETRICUS*

Smithers (1944), referring to *L. geometricus*, adequately describes how: "Within the area of a one-acre garden on the slopes of Table Mountain it was possible to collect a series of specimens whose individual colouration varied from pale yellowish white to almost jet black." Results obtained during this investigation when sampling populations in various areas confirmed Smithers' statement.

Of interest is the unrecorded observation that most specimens studied were found to match the ground colouration of their body to that of their habitat. Dark to almost jet black specimens were for instance very seldom found to have built a refuge on white or pale coloured walls. Similarly, the refuges of pale-yellowish specimens were scarce on dark structures.

L. geometricus, unlike certain Thomisids, cannot alter the ground colouration of its body, once it has reached maturity. It was found that all ground colouration changes took place with each moult. Certain specimens would eventually have a jet black colouration after the final moult while others would be pale yellow.

While as just stated, no adult female specimens of *L. geometricus* were ever observed to be capable of altering the ground colouration of their body, a peculiar and probably exceptional case is worthwhile mentioning. A light yellow adult female of *L. geometricus* who had fed on a praying mantis was found to have changed overnight to an almost black ground colour. Other pale yellow adult females of *L. geometricus* were subsequently also fed with praying mantis, but no changes in ground colour were observed.

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